Deploying HPC Environments in traditional facilities

Presented by: Ben Seager

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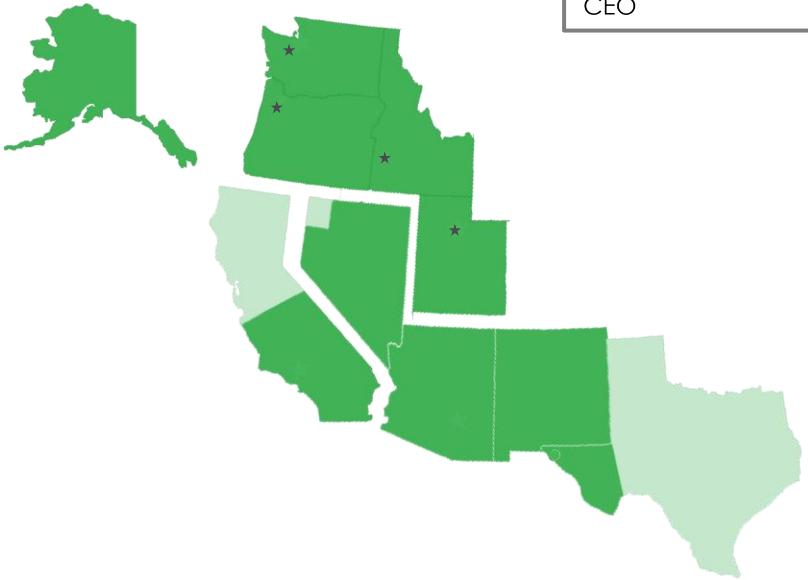

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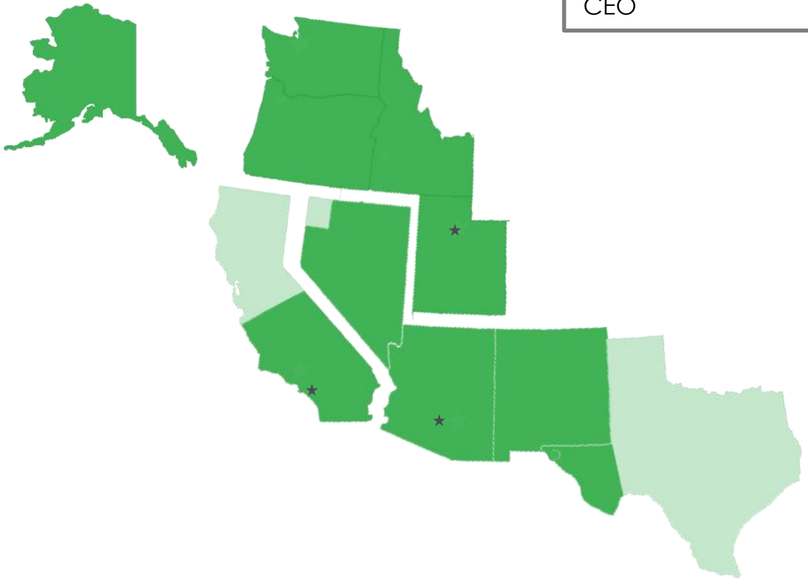

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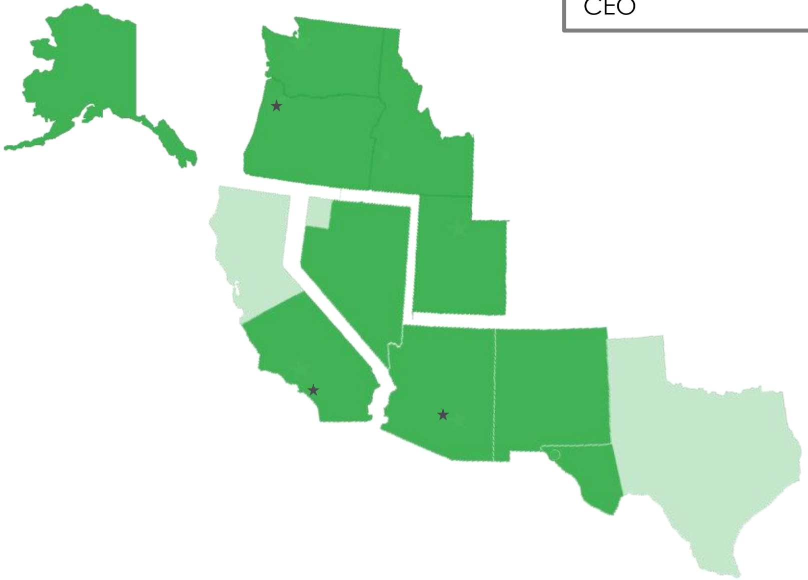

LDP's History & Profile

LDP Associates was founded as a **Manufacturer's Representative** in 1991 with an office in Phoenix supporting the Southwest

2001 expanded to a full data center offering (Power, Cooling, Software)

2010 Expansion to Southern California

2013 Acquired the PACNW and Intermountain States

Fortune 100 "Named Accounts" supported by factory direct sales and engineering teams. Everything else falls to LDP Associates to support

Focus on providing power and cooling for Mission Critical applications inclusive of:

- Data Centers *(UPS, In-row Cooling, Racks, rPDU, Software, Testing & Services)*

- Industrial *(UPS, Custom Enclosures, Design Support for Industrial use cases)*

- Commercial *(UPS, In-row Cooling, Turnkey Server Room Lab Environments, Services)*

- Government *(Complete Turnkey support of the above through various contract vehicles)*

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HPC – What is it?

Image – Ohio Supercomputer Center (OSC) 'Ascend' HPC Cluster

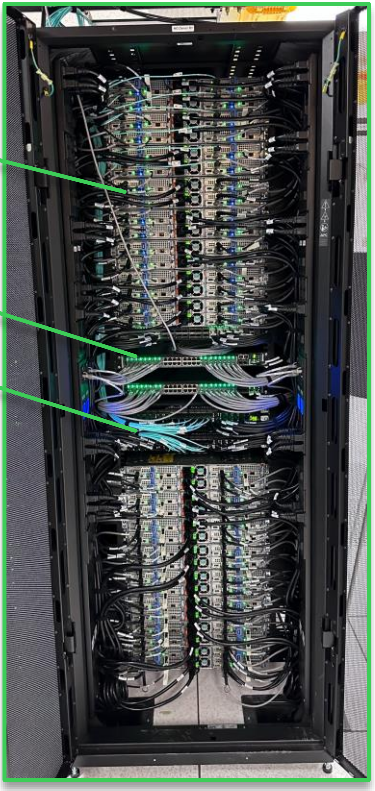
Physical Architecture Example

Dual Power Supplies are NOT always redundant!

Compute Servers

Networking

InfiniBand



Use caution when sizing off of Name Plate values.

Ex. 2400W * 2 * 16 = 76,800W peak

Work with your vendor to confirm how they intend on provisioning for your site.

-Redundant Power (yes/no)
-“Sled” configuration (RAM, CPU, GPU, Storage, Etc.)
-Calculated peak Watts

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Power Density

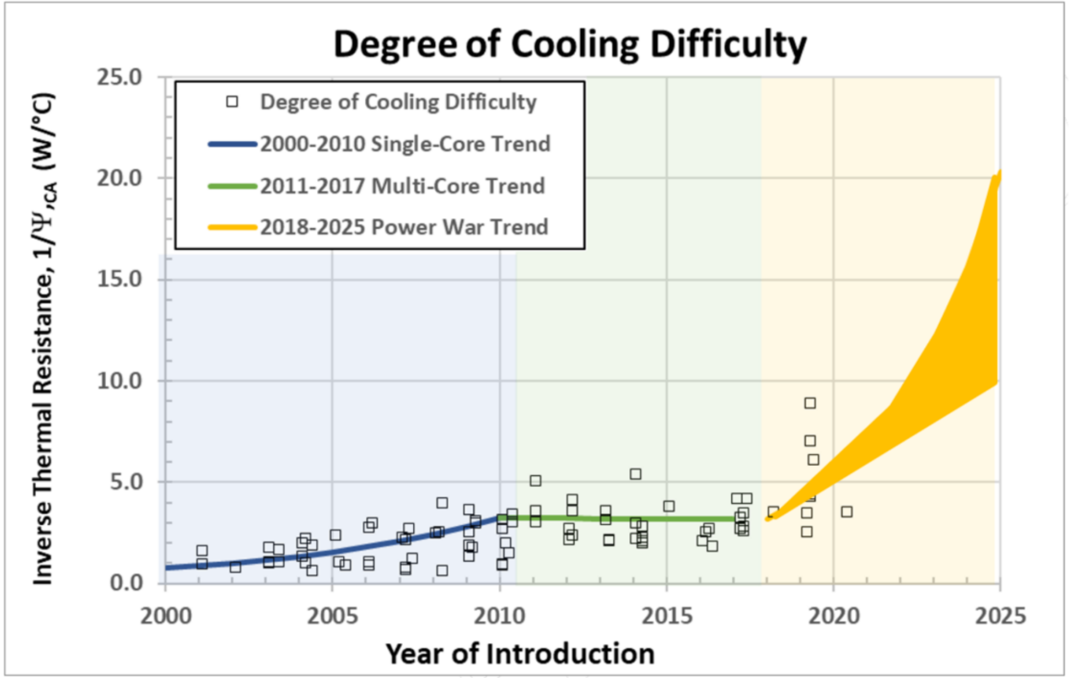
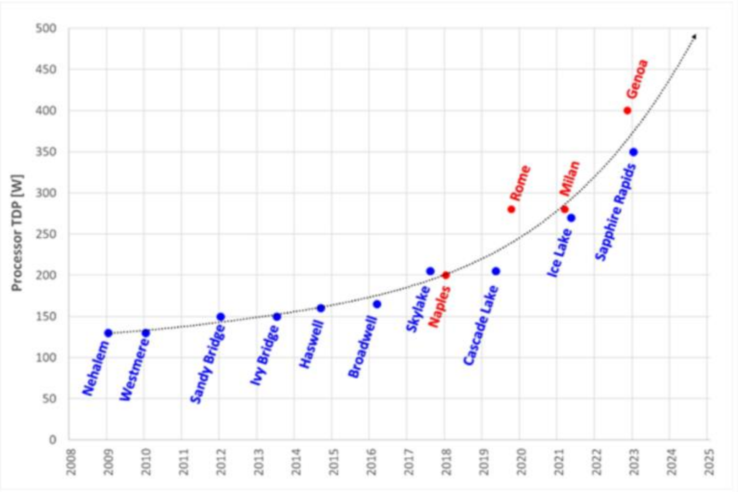


Figure 2 Degree of cooling difficulty for socket cooling, $1/\Psi_{ca}$.

Much like automotive manufacturer's competing on horsepower, so to are the chip manufacturers with their socket power density.

Not just multi-core chipsets, as device power must also increase for performance to increase.

Power Density



CPU Thermal Design Power (TDP) is continuing to increase.

Figure 4. R760xa chassis showing "first class seats" for GPU at the front of the system

IT'S NOT JUST THE CPU . . .

CPU Power	130W => 400W +
+	+
GPU Power	300W => 700W +
+	+
Memory Power	11.5W => 19.2W per DIMM
+	+
Storage Power	25W => 70W per Drive

Summary: Avoid Assumptions

Engage with your vendor team to confirm the expected power density based upon your actual build.

DELL The Future of Server Cooling Part 2

Calculations

35	Compute 32	Compute 64	Compute 96	Compute 128	Prov Agg 1
34	Compute 31	Compute 63	Compute 95	Compute 127	Mgmt Agg 1
33	Compute 30	Compute 62	Compute 94	Compute 126	
32	Compute 29	Compute 61	Compute 93	Compute 125	
31	Compute 28	Compute 60	Compute 92	Compute 124	
30	Compute 27	Compute 59	Compute 91	Compute 123	
29	Compute 26	Compute 58	Compute 90	Compute 122	
28	Compute 25	Compute 57	Compute 89	Compute 121	IB Core 1
27	Compute 24	Compute 56	Compute 88	Compute 120	IB Core 2
26	Compute 23	Compute 55	Compute 87	Compute 119	IB Core 3
25	Compute 22	Compute 54	Compute 86	Compute 118	IB Core 4
24	Compute 21	Compute 53	Compute 85	Compute 117	IB Core 5
23	Compute 20	Compute 52	Compute 84	Compute 116	IB Core 6
22	Compute 19	Compute 51	Compute 83	Compute 115	IB Core 7
21	Compute 18	Compute 50	Compute 82	Compute 114	IB Core 8
20	Compute 17	Compute 49	Compute 81	Compute 113	
19	Compute 16	Compute 48	Compute 80	Compute 112	
18	Mgmt Leaf 1	Mgmt Leaf 2	Mgmt Leaf 3	Mgmt Leaf 4	
17	Prov Leaf 1	Prov Leaf 2	Prov Leaf 3	Prov Leaf 4	
16	IB Leaf 1	IB Leaf 2	IB Leaf 3	IB Leaf 4	
15	Compute 15	Compute 47	Compute 79	Compute 111	
14	Compute 14	Compute 46	Compute 78	Compute 110	
13	Compute 13	Compute 45	Compute 77	Compute 109	
12	Compute 12	Compute 44	Compute 76	Compute 108	GPU Compute 1
11	Compute 11	Compute 43	Compute 75	Compute 107	
10	Compute 10	Compute 42	Compute 74	Compute 106	
9	Compute 9	Compute 41	Compute 73	Compute 105	
8	Compute 8	Compute 40	Compute 72	Compute 104	Viz Node 2
7	Compute 7	Compute 39	Compute 71	Compute 103	
6	Compute 6	Compute 38	Compute 70	Compute 102	Viz Node 1
5	Compute 5	Compute 37	Compute 69	Compute 101	
4	Compute 4	Compute 36	Compute 68	Compute 100	UFM Node 2
3	Compute 3	Compute 35	Compute 67	Compute 99	UFM Node 1
2	Compute 2	Compute 34	Compute 66	Compute 98	Head Node 2
1	Compute 1	Compute 33	Compute 65	Compute 97	Head Node 1
Compute Nodes	32	32	32	32	0
Compute Watts	28096	28096	28096	28096	0
Head Nodes	0	0	0	0	2
Head Watts	0	0	0	0	1820
UFM Nodes	0	0	0	0	2
UFM Watts	0	0	0	0	1700
Viz Nodes	0	0	0	0	2
Viz Watts	0	0	0	0	2810
GPU Compute	0	0	0	0	1
GPU Compute Wa	0	0	0	0	3550
Mgmt Switches	1	1	1	1	1
Mgmt Watts	200	200	200	200	200
Provisioning Swit	1	1	1	1	1
Provisioning Watt	200	200	200	200	200
Infiniband Switch	1	1	1	1	8
Infiniband Watts	400	400	400	400	3200
Total Rack Watts	**28896**	**28896**	**28896**	**28896**	**13480**

7.75 + 8.13 + 7.04 + 7.62
= **30.54kW** ***AT IDLE***

Hot Aisle (rear of ra

Rack 1 Compute	Rack 2 Compute	Rack 3 Fat Node	Rack 4 Core	Rack 5 FatNode	Rack 6 Compute	Rack 7 Compute

Cold Aisle (front of r

HVAC, Power & Weight Specs

	Totals	Rack 1	Rack 2	Rack 3	Rack 4	Rack 5	Rack 6	Rack 7
Watts	509,779.9	47,452.0	47,452.0	25,804.0	19,539.0	25,804.0	47,452.0	47,452.0
Amps	2,534.5	218.1	218.1	124.1	93.9	124.1	218.1	218.1
BTUs	1,738,915.0	161,913.0	161,913.0	88,047.0	66,669.0	88,047.0	161,913.0	161,913.0
Tons Cooling		13.5	13.5	7.3	5.6	7.3	13.5	13.5

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Airflow! Airflow! Airflow!

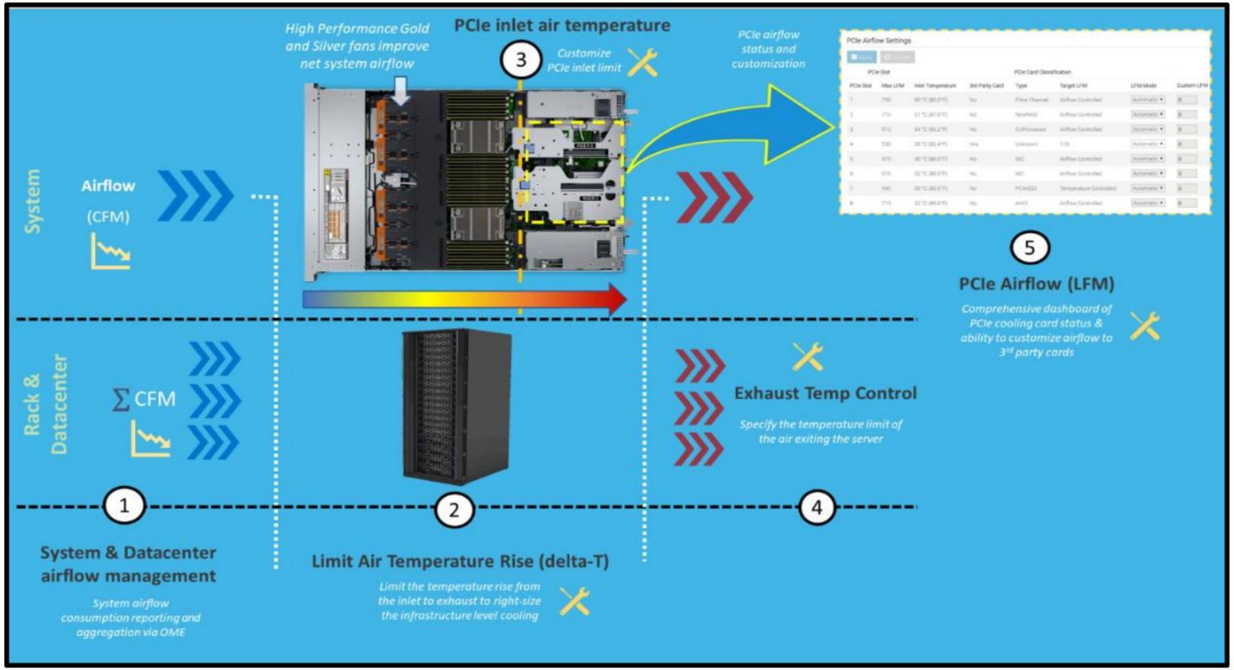


Figure 3 – iDRAC thermal management features and customizations

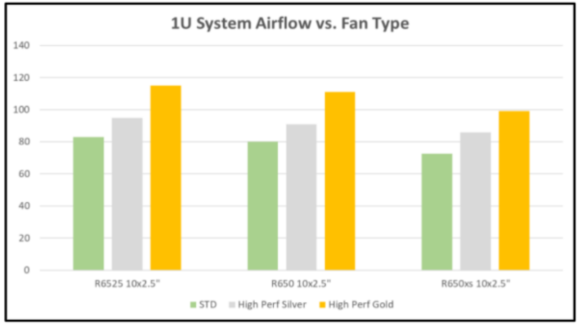


Figure 1 – Comparison of airflow output in CFM

Confirm how the system will be configured and if CFM control is available. Exercise caution when estimating CFM.

Dell Technologies – Multi Vector Cooling 2.0 for Next-Gen PowerEdge Servers

ASHRAE Recommendations

HP HPC Example

ASHRAE 2021 Recommendations

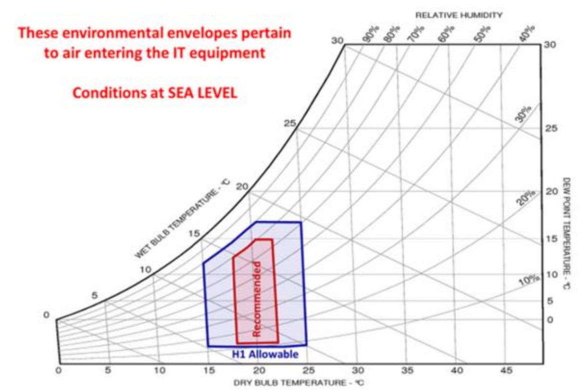


Figure 2.6 2021 recommended and allowable envelopes for ASHRAE Class H1. The recommended envelope is for low levels of pollutants verified by coupon measurements as indicated in note 3 of Section 2.2.

Table B.1 2021 Thermal Guidelines for Air Cooling— I-P Version (SI Version in Chapter 2)

Equipment Environment Specifications for Air Cooling							
	Product Operation[b,c]					Product Power Off[c,d]	
Class[a]	Dry-Bulb Temp.[e,g], °F	Humidity Range, Noncond.[h,i,k,l,n]	Max. Dew Point[k], °F	Max. Elev.[e,j,m], ft	Max. Rate of Change[f], °F/h	Dry-Bulb Temp., °F	RH[k], %
Recommended (suitable for Classes A1 to A4; explore data center metrics in this book for conditions outside this range.)							
A1 to A4	64.4 to 80.6	15.8°F DP to 59°F DP and 70% rh[n] or 50% rh[n]					
Allowable							
A1	59 to 89.6	10.4°F DP and 8% rh to 62.6°F DP and 80% rh[k]	62.6	10,000	9/36	41 to 113	8 to 80[k]
A2	50 to 95	10.4°F DP and 8% rh to 69.8°F DP and 80% rh[k]	69.8	10,000	9/36	41 to 113	8 to 80[k]
A3	41 to 104	10.4°F DP and 8% rh to 75.2°F DP and 85% rh[k]	75.2	10,000	9/36	41 to 113	8 to 80[k]
A4	41 to 113	10.4°F DP and 8% rh to 75.2°F DP and 90% rh[k]	75.2	10,000	9/36	41 to 113	8 to 80[k]

* For potentially greater energy savings, refer to Appendix C for the process needed to account for multiple server metrics that impact overall TCO.

Table B.2 2021 Thermal Guidelines for High-Density Servers— I-P Version (SI Version in Chapter 2)

Equipment Environment Specifications for High-Density Air Cooling							
	Product Operation[b,c]					Product Power Off[c,d]	
Class[a]	Dry-Bulb Temp.[e,g], °F	Humidity Range, Noncond.[h,i,k,l,n]	Max. Dew Point, °F	Max. Elev.[e,j,m], ft	Max. Rate of Change[f], °F/h	Dry-Bulb Temp., °F	RH, %
Recommended							
H1	64.4 to 71.6	15.8°F DP to 59°F DP and 70% rh[n] or 50% rh[n]					
Allowable							
H1	59 to 77	10.4°F DP and 8% rh to 62.6°F DP and 80% rh[k]	62.6	10,000	9/36	41 to 113	8 to 80[k]

Recommended
64.4 – 71.6F
Allowable
59 – 77F

ASHRAE Thermal Guidelines for Data Processing Environments, 5th Edition

ASHRAE 2021 Recommendations

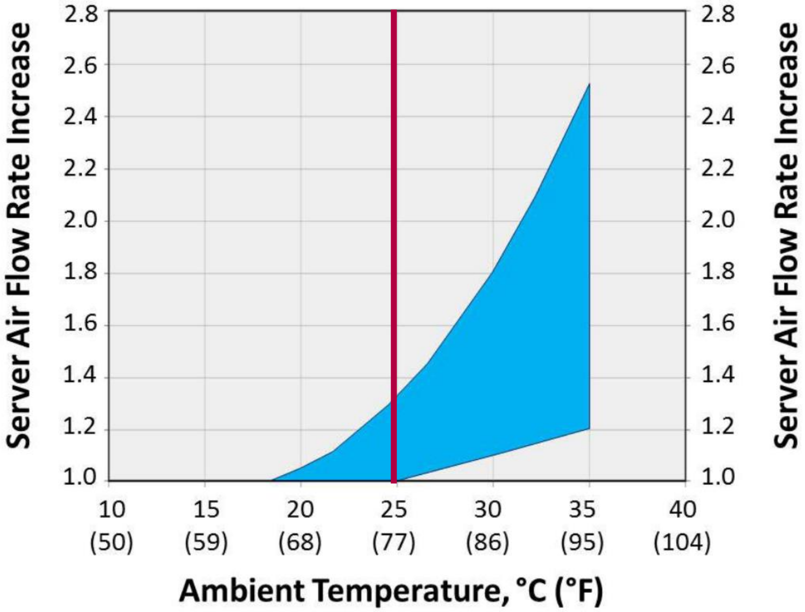


Figure 2.10 Server flow rate increase versus ambient temperature increase.

Max Room Setpoint = 77F

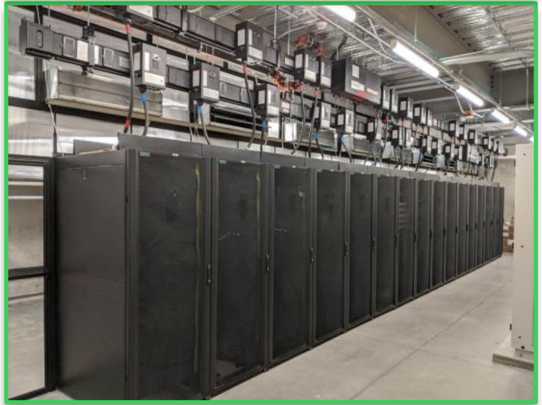
While ASHRAE allows for a wide operating temperature for some equipment class types, the H1 High Density recommendation is more conservative.

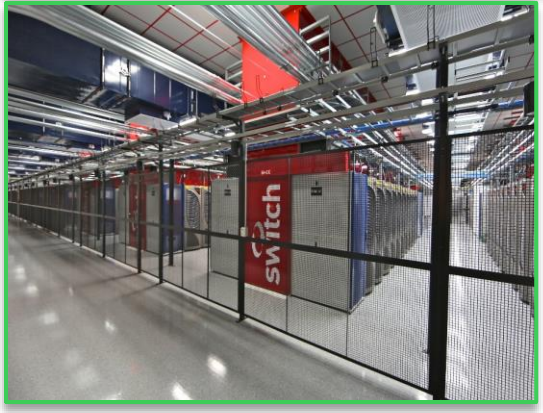
This is for both equipment fan efficiency and to keep fan noise in check.

ASHRAE Thermal Guidelines for Data Processing Environments, 5th Edition

Existing Physical Infrastructure

What does your facility look like?





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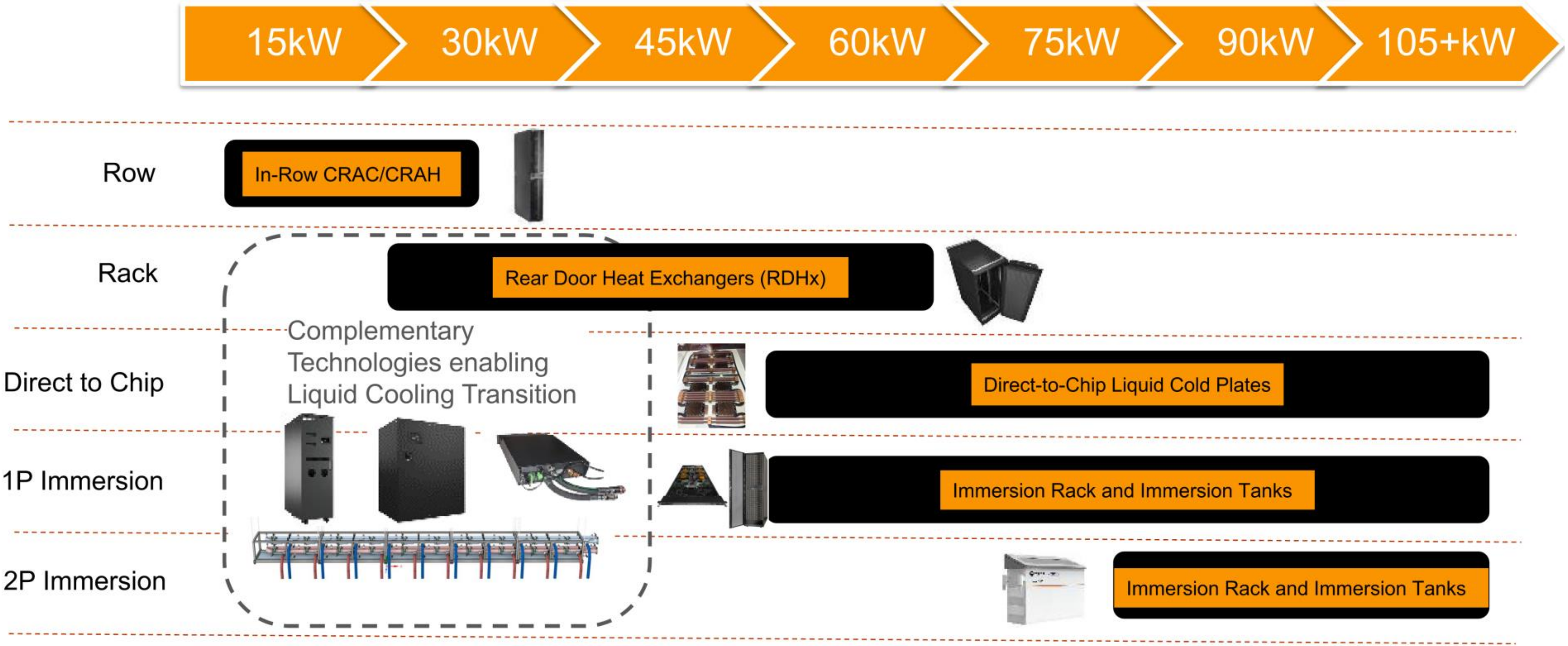
High Density and Liquid Cooling Technologies



Vertiv – Liquid Cooling: Why it's making such a splash in Data Centers

Device Level Power Density

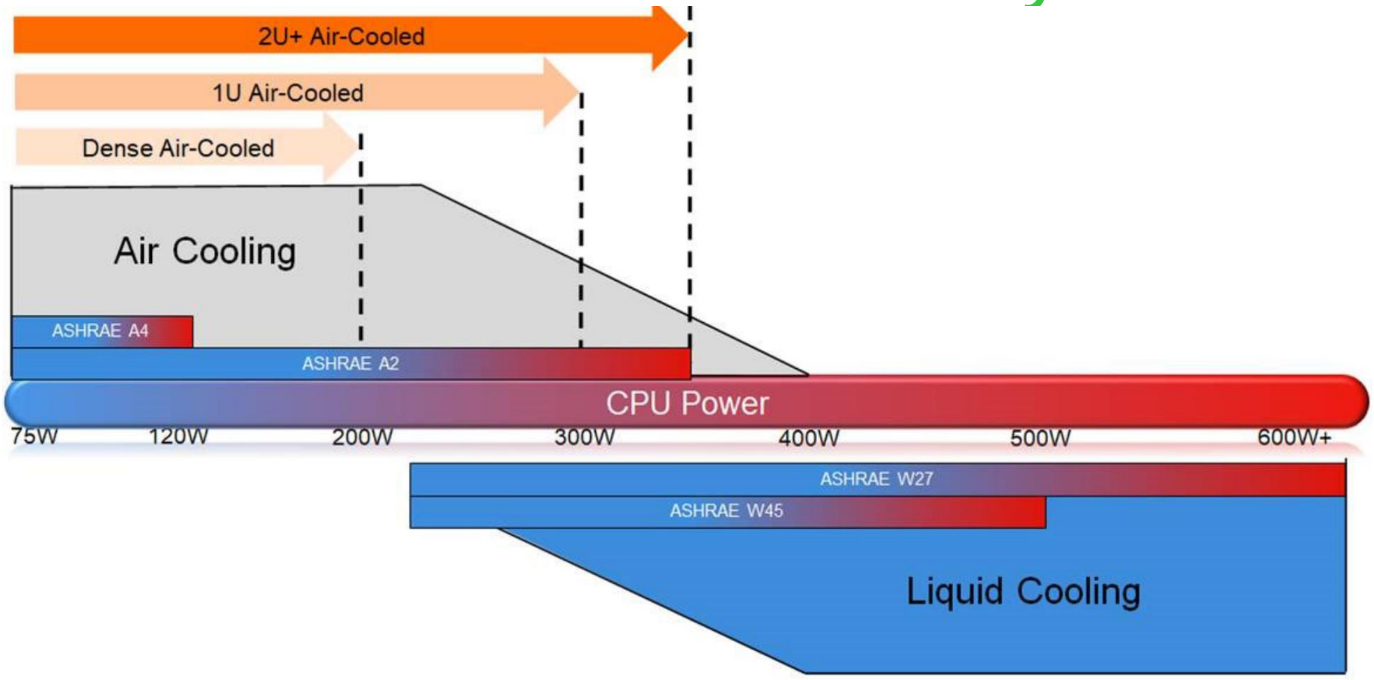


Figure 4 Air cooling versus liquid cooling, transitions, and temperatures.

ASHRAE – Emergence and Expansion of Liquid Cooling in Mainstream Data Centers

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Mechanical

Do you have an existing chilled water plant?

- If your facility uses water side economization your economizing hours may be reduced as facility LWT is lowered to support higher socket power requirements.
- Review both supply and return temperatures, as some systems may work well on the RETURN water loop.
- Be observant with water velocities, as the volume of water required can increase significantly further down the mechanical distribution system than historical averages with CRAHs.

Pipe Size		ASHRAE 90.1-2019 Table 6.5.4.6		Equiv Velocity		ΔT				
						4	6	8	10	C
						7.2	10.8	14.4	18	F
DIN	in	l/s	GPM	m/s	ft/s *	Max kW				
50	2	4.95	78	2.3	7.5	83	124	166	207	
65	2-1/2	6.94	110	2.2	7.4	116	174	232	290	
80	3	10.73	170	2.2	7.4	180	269	359	449	
100	4	20.19	320	2.5	8.1	338	507	676	845	
150	6	42.90	680	2.3	7.6	718	1077	1436	1795	
200	8	69.40	1100	2.1	7.1	1162	1742	2323	2904	
250	10	100.94	1600	2.0	6.5	1690	2534	3379	4224	
300	12	145.11	2300	2.0	6.5	2429	3643	4858	6072	

Based on flow rates per ASHRAE 90.1-2019 Table 6.5.4.6 for Variable Flow

* - Values are based on standard weight carbon steel pipe dimensions, ASTM A53

Represents typical design dT for chiller-based systems

Represents dT lower than typical design/operation of FWS systems

Raised Floor

- Air side requirements with raised floor spaces can be challenging both with velocity and volume.
  - Ex: Assume 100CFM per 1RU of compute = ~3500 CFM for a ~30kW rack
  - Max high flow tile = 1,900 CFM, but <1,000 CFM is more typical
  - Ex: 130CFM per kW

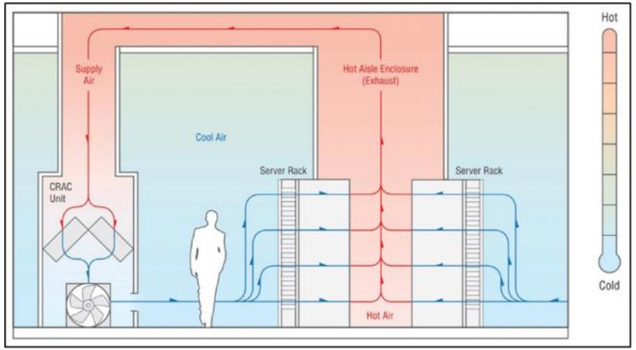

Figure 3. Hot aisle containment enclosure diagram, sourced from Uptime Institute

Air/Water Cooled DX

- Possible, but highly inefficient in comparison to liquid cooling solutions

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Electrical

415V vs 208V when possible

- 60A * 1.73 * 208V = 21,590W * 0.8 = 17.3kW rPDU per 3P60A Circuit
- 60A * 1.73 * 415V = 45,230W * 0.8 = 34.6kW rPDU per 3P60A Circuit
- 63A * 1.73 * 400V = 45,230W * 1.0 = 43.5.kW rPDU per 3P63A Circuit

Look UP the electrical distribution system

- Pay attention to not just the branch circuit capacity, but the associated subfeed breakers through the PDU to the UPS. Diversification at the PDU panel level is likely.

Not Always dual corded for redundancy

- Confirm with the vendor if the dual power supplies will be for capacity or redundancy
- Watch for subfeed breakers that are just 80% rated vs 100%

480V is available in some cases

- Watch for the available fault current, as some sites might pose pragmatic withstand rating requirements.

Sound and Temperature Levels

Facility room setpoints might need to be lowered to below 77F

- Device level fan energy and CFM requirements contribute to the H1 (64.4F – 71.6F) recommended allowable range. As the fan speed increases, so does the noise emission level.

Table 2.5 Expected Increase in A-Weighted Sound Power Level

25°C (77°F)	30°C (86°F)	35°C (95°F)	40°C (104°F)	45°C (113°F)
0 dB	4.7 dB	6.4 dB	8.4 dB	12.9 dB

CRAH Fans Speeds

- For air cooled environments the CRAH fans also contribute to the noise level

Hot Aisle Temperature and Sound levels

- Per ASHRAE, 84 dB can be expected at 77F in the hot aisle
- Assume 25 or 30F Delta T, so a room set point of 75F could realistically produce a 105F hot aisle

Resources

ASHRAE

- 2021 Equipment Thermal Guidelines for Data Processing Environments, 5th Edition
  https://www.techstreet.com/standards/thermal-guidelines-for-data-processing-environments-5th-ed?product_id=2212974
- 2021 Equipment Thermal Guidelines for Data Processing Environments, 5th Edition
  https://www.ashrae.org/file%20library/technical%20resources/bookstore/emergence-and-expansion-of-liquid-cooling-in-mainstream-data-centers_wp.pdf

Dell Technologies

- The Future of Server Cooling – Part 1
  https://infohub.delltechnologies.com/p/the-future-of-server-cooling-part-1-the-history-of-server-and-data-center-cooling-technologies/
- The Future of Server Cooling – Part 2
  https://infohub.delltechnologies.com/p/the-future-of-server-cooling-part-2-new-it-hardware-features-and-power-trends-1/

APC by Schneider Electric

- White Paper 46 – Cooling Strategies for Ultra-High Density Racks and Blade Servers
  https://www.se.com/us/en/download/document/SPD_SADE-5TNRK6_EN/
- White Paper 279 – Five Reasons to Adopt Liquid Cooling
  https://www.apc.com/us/en/download/document/SPD_WTOL-B9RKEA_EN/

OPEN Compute Project

- Data Center Liquid Distribution Guidance & Reference Designs
  https://www.opencompute.org/projects/cooling-environments